THE UNIVERSAL SCREW FOR MICROSCOPE-OBJECTIVES.

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Working microscopists in general and manufacturers in particular have for a long time been worried by the variations which exist in the so-called Universal, or Society, screw. Those who have had occasion to use objectives from different makers on one instrument are aware that while some would enter the screw easily—too easily, perhaps—others would not come to the shoulder, or would not begin to enter. A short time ago I had in my possession five different screws, made by as many reputable makers, and only one entered the screw which had been cut by a tap just received from England.

We have always been proud to consider the microscope a delicate instrument of research; it undoubtedly is such, and while in most respects it is as nearly perfect as the highest mechanical skill and ingenuity can attain, it is deficient in this important part; here it should be absolutely free, not only from a probability but even from the remotest possibility of a variation. Complaints have been and are numerous, but they seem to have been of no avail. To the best of my knowledge no effort has been made to determine the cause of the evil, nor has any attempt been made to remedy it. I have taken the matter up from compulsion, and have given it as much time as I could devote to it, although not enough to fully cover the subject. The first point was to determine what the Universal screw was, and by the courtesy of Dr. R. H. Ward I was furnished with the report of the committee which recommended it to the Microscopical Society. This report was made November 12, 1857, and reads as follows:

"The practical inconvenience that has arisen from the adoption,

by different makers, of various modes of attaching object-glasses, has long since been universally admitted. In recommending a form of attachment for general adoption, it appears necessary to consider the following conditions:

"1. That the greatest amount of truth be insured, both in centering and in the parallelism of the axes of the body and object-glasses.

"2. That the linear aperture be large enough to transmit all the pencils that can fall upon any field-glass in ordinary use.

"3. That the fitting must be capable of construction in an ordinary lathe.

"In order to insure parallelism of the axes, a face-fitting is generally considered necessary. It also appears desirable that the inside fitting should be in the body of the microscope and the outside fitting on the object-glass. Of the various modes of attachment that have been suggested, that which appears likely to fulfill most completely the conditions of perfect centering, is a cone of about 40°, surmounted by a screw which enters a loose nut placed above the hollow cone in the body of the microscope, but the practical difficulties of manufacture appear insurmountable; it is therefore proposed, for the greater degree of accuracy that might thus be obtained, in favor of a mode of fitting that is at present partially in use, namely, a screw surmounted by a plain collar, or guide, for facilitating the application of the object-glass. As the correct centering must practically depend on the screw, it is strongly recommended that the inside and outside screws should both be cut by a traversing mandrill or by a traversing slide-rest. Having thus considered the form of the attachment, it remains to determine the most appropriate dimensions of the several parts. A screw, containing 36 threads to the inch, having an angular thread of 54°, slightly rounded off at the top and bottom, has been considered the most appropriate. The largest linear aperture, at the junction of the object-glass with the body of the microscope, will be required for objectives of low power having the widest compatible angle of aperture; this is not likely to exceed .72 to .73 inch with the greatest diameter of field-glasses now in use; hence .8 inch may be taken as sufficient for the external diameter of the screw. The

length of screw recommended is 1-8 or .125 inch comprising four and one-half threads, and that of the guide or collar .15 inch."

In the spring of 1859, Mr. Richard Beck read a paper on getting reliable threads, and in answer to this another report was made by the committee, which reads as follows: "As some remarks contained in this paper imply a want of due consideration on the part of the committee to whom the subject of the standard screw was referred, in substituting a tap and a pair of screw tools for the cylindrical guages and hob recommended in their first report, it appears not undesirable to state the motives which induced them to adopt this course. It is unquestionable that an exact counterpart of the hob *may* be made by a screw-cutting lathe; but for so fine a thread, screw tools may probably be equally well hand-made by a practical workman. As very few opticians either possess traversing lathes or have had much experience in making screw-tools, it was thought more desirable to have some screw-tools made from Whitworth's hob by an experienced workman and supply them at cost price to the manufacturers. The practical difficulties that occurred in the use of the cylindrical gauges may be thus explained. It is manifest that if the inside and outside screws were exactly the same size, that is, had exactly the same longitudinal section, they would fit each other as tightly as the cylindrical gauges, and would, therefore, be useless for the purpose proposed. One of three courses must therefore be adopted, either (1) the outside screw being made to the exact gauge size, the inside screw must be a little larger; or (2) the inside screw being made to the exact size, the outside screw must be made a little smaller, or (3) both inside and outside screws must be made to vary a little from the exact size. It soon occurred in practice that object-glasses by one maker who adopted the first course, would not enter the body of a microscope by another maker who adopted the second course, and thus the proposed universality of the screw was so far set at naught. As both the top and the bottom of the outside screw can be most easily gauged, it appeared to the committee more desirable to adopt the first course, by giving a little ease to the inside screw, and in order to insure uniformity, to have a number of steel taps or gauges made of such a size that if the body of the microscope were made

to receive one of them tightly, an object-glass having an outside screw of the exact proposed dimensions would enter it easily and pleasantly. These taps must necessarily, for the reasons previously stated, be some two or three thousandths of an inch larger than the gauge size."

In effect, the thread recommended is the Whitworth thread, which I believe is in general use in England. I wish to draw particular attention to some portions of these reports. The first is that which says that the thread should be "slightly rounded." "Slightly" is ambiguous, and exceedingly so when reference is made to the microscope; further than this, if .8 inch should be the outside diameter, it is impossible to say what it should be under these conditions. In the second report it is recommended that the plug, which sizes the thread in the nose-piece, should be two or three one-thousandths larger than .8 and this leaves considerable room for variation. These directions for making a standard screw, in the words of this report, are so indefinite that it seems to me utterly impossible to follow them and gain reliable results, and I suppose it is for this reason that the Royal Microscopical Society furnishes a standard plug or tap. These taps are stamped with the initials of the Society, and are furnished by its Secretary, and I suppose that it may be fairly assumed that they are made by the sanction of the Society, if not by its authority. In addition to one which we had in our possession, I sent for two more for comparison; they are now in exactly the same condition in which we received them. On examination I find the following discrepancies:

1. They are both tapering; the variation in .5 inch length of screw being .005 inch.

2. They are not round, the difference between the largest and smallest diameter in one tap being a little over .001 inch.

3. They are unlike in diameter at their largest diameters, one measuring .8 and .003 inch, while the other is exactly .8 inch.

4. The threads do not correspond, which is evidence that either the angles vary or that they are irregular.

A glance at the above table explains the differences among the various makers and the variations which may take place in the course of time in the sizes of one maker; for if we assume that the

largest diameter of the plug is the correct size, whether it is used for cutting the thread or sizing it, it is evident that this diameter will decrease with limited use, from the fact that there is but a small surface exposed to friction. With the irregularity of the threads, I venture to say, although I have not given them sufficient examination to do so positively, that .002 or .003 inch, which are now added to the plugs, would not be sufficient to allow an objective with a correct screw to enter easily.

The threads were unquestionably cut with great care at the outset, and the variations are, no doubt, owing to the changes during the process of hardening. Still, the fact exists that they are not accurate; they should never have been sent out as standards, and should not be accepted as such. Twenty-five years ago there was probably no remedy for this, but since then enormous improvements have been made in mechanical devices, and with the facilities now at hand such faults find no excuse. The method which is almost universally used in this country for making screws and plugs and dies, is to grind them accurately to their proper sizes *after* they have been hardened. Such accuracy is attained in this manner that .0001 inch variation is considered a grave error; for instance, a plug and die which are mated, are fitted so closely that at a normal temperature they slide easy, one in the other, while if the plug be held sufficiently long in the hand to impart the heat of the body to it, it cannot be withdrawn if in the die, or made to enter if out. This, it appears to me, should be the accuracy which should be aimed at in any gauge or standard for the microscope. We should not be compelled to labor continually under the depressing conviction that in making such delicate instruments as microscopes and objectives we are compelled to rely upon tools which are vastly inferior to those used in other branches of mechanics. I have endeavored to approach this perfection, but am sorry to say that the time has been too limited to enable me to exhibit any practical results.

In order to get a starting-point, it was necessary to determine what the Whitworth thread was, and this I found to be 2-3 that of a V thread at 55° angle. Prof. W. A. Rogers kindly offered his assistance, and has made for me a four-inch bar divided into 36 parts to

the inch. Using this as a standard, the Ballou Manufacturing Company is now making a standard die for .8 inch diameter of screw and a plug .001 larger, both of which will be ground to size and shape after they have been hardened. I conceive it to be as necessary, or perhaps more so, to have a standard for the objective as well as for the nose-piece; and .001 inch is, in my opinion, sufficient for the difference, so that every objective which is correct in size will enter the nose-piece. Mr. Geo. F. Ballou has promised that the tap and die should be absolutely accurate, and I expect them to be so. As I said, they are not quite complete, but they may possibly arrive before the adjournment of the Society. Although the threads on the microscopes will be cut by screw-cutting lathes, and great exactness will be observed in the work, I apprehend considerable difficulty in following the accuracy of the standards on account of the rounded threads. I cannot do better than to read a report of the United States Navy Department bearing on this subject in this connection :

" In regard to the execution of the Whitworth form of thread, we remark that its angle is such as not to admit of ready verification, and its curved top and bottom require such a multiplicity of special tools and such skill on the part of the workman, that the requisite degree of uniformity of practice among different manufacturers is believed to be entirely impracticable, if not 'impossible.' Among all the establishments visited or communicated with by us, only one has been found where this form of thread is used. We refer to the printing-press manufactory of R. Hoe & Co., of New York City, where this thread has been in use about thirty years. The fact that this thread, in itself undoubtedly the best form ever proposed, has been so long before the public and has met with so little favor among our engineers, is of itself the strongest and most conclusive argument that can be urged against its practicability."

I do not think anything can be added to these words to give them force. I believe the time is ripe for decisive action on the question of a new Universal screw. Opticians are, at present, hampered by the small size of the present one, and will become more so as advances are made in practical optics. Dr. Butterfield's suggestion of the 1.25 inch screw was admirable, and I believe only failed to become

generally adopted because of its excessive size. We need a screw which is larger than .8 inch, but still of such a size that it can be universally applied to instruments as now made. It is only a question of time when such a screw will of necessity be adopted, and the longer it is delayed the greater will be the difficulties of effecting a change. Our Society should communicate with the Royal Microscopical Society and endeavor to persuade it to act in conjunction with it. If the members will give the taps, as now made and sent out, an examination, they cannot but be convinced of the necessity of improving them, and if the mechanical difficulties in duplicating them *are* considerable, they may be favorably inclined to a new thread. It is but proper that the parent society should take initial steps on this question, but if this should not be done, I believe that it is in the province of this Society to take decisive action in a matter which cannot fail to become universally beneficial.